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(54) **Method and pharmaceutical composition for preventing and/or treating systemic inflammatory response syndrome**

(57)   A partial inhibitor of factor VIII such as a monoclonal antibody is useful for preventing and/or treating a disease selected from the group consisting of systemic inflammatory response syndrome, sepsis, septic shock, thrombus formation in the micro-vasculature and disseminated intravascular coagulation in a mammal by partially inhibiting thrombin formation.

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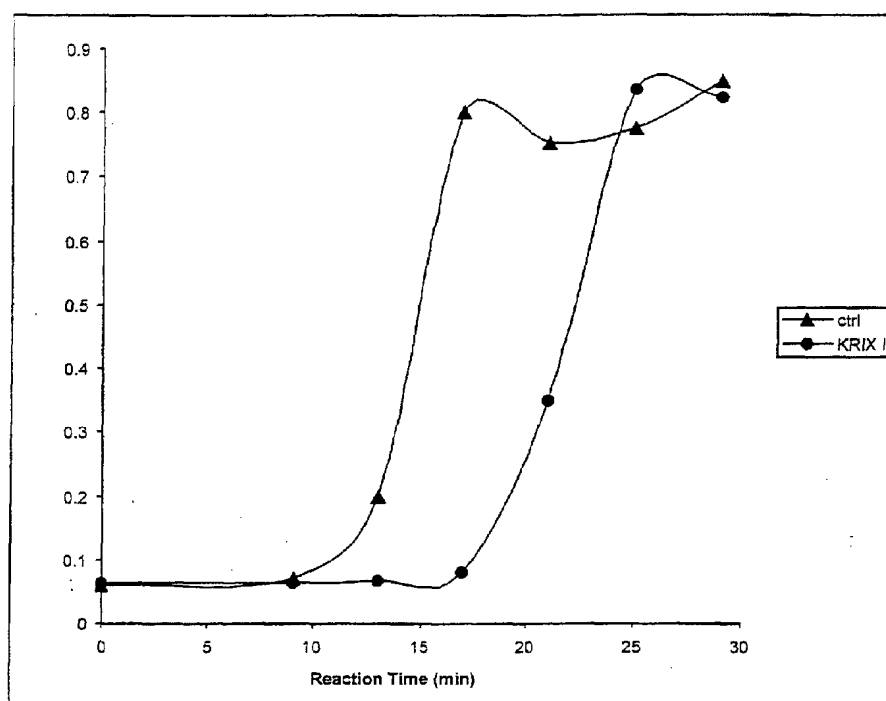
Description

[0001] The present invention relates to the prevention and/or treatment of systemic inflammatory response syndrome in mammals. The invention further relates to pharmaceutical compositions for the therapeutic treatment of sepsis and/or septic shock, as well as thrombus formation in the microvasculature and/or disseminated intravascular coagulation in mammals.

BACKGROUND OF THE INVENTION

[0002] Systemic inflammation is the possible endpoint of a number of clinical conditions including pancreatitis, ischemia, multiple trauma and tissue injury, haemorrhagic shock, immune-mediated organ injury and infection. Since quite comparable pathological changes are observed in systemic inflammation independently of the initial cause, the term "systemic inflammatory response syndrome" (hereinafter referred as SIRS) has been commonly quoted to account for such changes and is therefore used in the present application in accordance with the recommendations of the American College of Chest Physicians as formulated by R.C.Bone et al. in *Chest* (1992) 101:1644-55.

[0003] Sepsis represents a SIRS associated to infection. Shock, whether of septic origin or not, is characterized namely by (a) hypotension persisting despite adequate fluid resuscitation and (b) abnormalities related to hypoperfusion or organ dysfunction.

[0004] SIRS, and sepsis in particular, is a quite frequent disorder. Recent estimates have indicated that about 400,000 cases of sepsis are diagnosed every year in the United States of America, with about 50% of them evolving to septic shock. The latter is associated with a mortality rate of about 50%. Furthermore, the frequency of sepsis and septic shocks is increasing despite the use of efficient antibiotic therapy and resuscitation measures based on recent understanding of the patho-physiology of sepsis and its complications. This frequency increase is thought to be related to an increased number of immuno-compromised patients, an expanding population of elderly patients and a significant resistance to some anti-microbial therapies.

[0005] According to Bone et al. in *Chest* (1997) 112:235-43, the early systemic inflammation, which is an integral part of SIRS, is normally compensated by a later anti-inflammatory response. An equilibrium between pro-inflammatory and anti-inflammatory events leads to a favorable clinical outcome. However, the balance between these two antagonistic events is fragile and easily disrupted, since many interacting mediators are involved.

[0006] In recent years much knowledge has accumulated about the patho-physiology of SIRS and the development of related septic shock, the paradigm of which is due to infection with gram (-) microorganisms. Thus endotoxins liberated by such microorganisms activate a number of host cells and in particular monocytes and macrophages. This results in the production of pro-inflammatory cytokines including tumor necrosis factor (hereinafter referred as TNF), interleukins 1, 6 and 8 (hereinafter referred IL-1, IL-6 and IL-8). Enzymes produced by the same cells lead to activation of the coagulation, complement and bradykinin systems. Superoxide radicals and metabolites of arachidonic acid, including platelet activating factor (hereinafter referred as PAF) are produced according to Parillo et al. in *Ann. Intern. Med.* (1990) 113:227-242.

[0007] Activation of the coagulation system together with adhesion of polymorphonuclear cells and platelets to the vascular endothelium is essential in the pathogenesis of SIRS since it results in the formation of thrombus in the microvasculature. Thrombi impair organ perfusion, which ends up with organ dysfunction or failure. At the intestinal level, this produces an increased absorption of endotoxins from the bacterial flora, which further boosts the release of pro-inflammatory cytokines and organ dysfunction. The disseminated intravascular coagulation (hereinafter referred as DIC) is therefore an essential component of the pathophysiology of sepsis and septic shock.

[0008] A compensatory anti-inflammatory response emerges later, from which the clinical outcome of sepsis will depend. Too weak or too strong responses can aggravate the clinical situation by failure to control DIC or by leading to uncontrolled bleeding and immune suppression with increased susceptibility to further infection. The individual factors intervening in this anti-inflammatory phase are not all identified with certainty but a number of molecules have been clearly implicated. Thus the levels of anti-thrombin (hereinafter referred as AT, a plasma serine protease inhibitor with a normal plasma concentration of 3 μmol/L), activated protein C (APC) and tissue factor pathway inhibitor (hereinafter referred as TFPI, another endothelial-bound protein), three potent inhibitors acting at various steps in the co-agulation cascade, are severely reduced during sepsis and their plasma concentrations are inversely correlated with bad clinical prognosis according to E.F. Mammen in *Intensive Care Med.* (1998) 24:649-50. Such reduced levels are due both to increased consumption and reduced synthesis, namely by the liver.

[0009] The coagulation system is currently divided in an initiation phase, an amplification phase and an effective phase. Initiation occurs by activation of factor VII on tissue factor (TF) or by the contact factor XII. This results in the generation of small amounts of thrombin, which activates an amplification loop leading to more thrombin formation. Two co-factors in this amplification loop, factor V and factor VIII, are activated, their function being to increase by several logs of magnitude the cleavage of prothrombin and factor X respectively. The effective phase of the coagulation

cascade eventually leads to the formation of fibrin and clot retraction. Thrombin therefore occupies a central role in the development of DIC associated with sepsis or SIRS of other origin. This discovery has led to therapeutic attempts to reduce thrombin formation. In humans, studies comparing antithrombin with a synthetic protease inhibitor (Maki et al. in *Gynecol. Obstet. Invest.* (1987) 23:230-240) or heparin (Blauhut et al. in *Thromb.* Res. (1985) 39:81-89) documented a significant attenuation of disseminated intravascular coagulation after antithrombin treatment, but neither included a placebo control group. According to Fourrier et al. in *DIC*, Excerpta Medica, Amsterdam (1993) 221-226, a placebo-controlled, double blind trial in patients with septic shock and DIC treatment with a plasma concentrate of antithrombin achieved significantly earlier correction of DIC but failed to decrease mortality in a significant manner. More recently, plasma-derived or recombinant AT have been tested in the control of sepsis, namely according to Eisele et al. in *Intensive Care Med.* (1998) 24:663-72. However all these embodiments encountered serious problems. Natural plasma antithrombin is a relatively poor inhibitor of thrombin (it achieves full inhibition of thrombin, but only at very high concentrations), but its inhibitory effect is increased 10,000 fold in the presence of heparin. High concentrations of antithrombin are necessary to prevent shock in animal models of sepsis, according to Büller et al. in *Am. J. Med.* (1989) 87:44-48 and Vinazzer in *Clin. Appl. Thromb/Hemost.* (1995) 1:62-65. Because of the moderate survival time of antithrombin in the circulation (a half-life of about 3 days was reported by Schwartz et al. in *Am. J. Med.* (1989) 87:53-60 and Menache et al. in *Blood* (1990) 75:33-39) and its consumption in SIRS, its activity should be monitored regularly. Theoritically, combined antithrombin and heparin therapy should be more effective than antithrombin alone in the management of shock, but unfortunately this form of treatment did not improve the outcome in shocked patients and was associated with an increased risk of bleeding.

[0010]   Therefore there remains a strong need in the art for a safer and more effective therapy and/or prevention of a systemic inflammatory response syndrome and related shock and, more specifically, for the treatment of blood circulation disorders following a systemic infection with gram (-) microorganisms.

SUMMARY OF THE INVENTION

[0011]   According to the present invention, factor VIII is however a more appropriate target in order to maintain the rate of thrombin formation under control in mammals. This is namely because factor VIII acts as a cofactor in the formation of the tenase complex, i.e. the enzyme which activates factor X, which in turn converts pro-thrombin into thrombin in the presence of factor V. As a co-factor, factor VIII is not absolutely required for the generation of thrombin and some coagulation still occurs in its absence. On the other hand, according to M. Hultin in *J. Clin. Invest.* (1981) 69:950-8, factor VIII increases by 100,000-fold the rate of tenase formation. Therefore the present invention is based on controlling the activity of factor VIII, this being an efficient way to slow down the formation of thrombin. More broadly, this invention is based on partially inhibiting the formation of thrombin (i.e. decreasing or reducing the rate of thrombin formation) rather than fully inhibiting said formation as is achieved by antithrombin or a heparin-antithrombin combination.

[0012]   The present invention first provides a method for preventing and/or treating a systemic inflammatory response syndrome (SIRS) in mammals by (i.e. the said method comprising or, preferably, consisting essentially of) partially inhibiting the formation of thrombin, for instance by administering a partial inhibitor of factor VIII to the mammal in need thereof. This invention also provides a method for preventing and/or treating sepsis and/or septic shock in mammals by administering a partial inhibitor of factor VIII to the mammal in need thereof. Another object of the present invention is a method for preventing and/or treating thrombus formation in the micro-vasculature in mammals by administering a partial inhibitor of factor VIII to the mammal in need thereof. A further object of the present invention is a method for preventing and/or treating disseminated intravascular coagulation in mammals by administering a partial inhibitor of factor VIII to the mammal in need thereof. Yet another object of the present invention is a method for restoring the plasma level of anti-thrombin and/or activated protein C and/or tissue factor pathway inhibitor in mammals by administering a partial inhibitor of factor VIII to the mammal in need thereof. This invention additionally provides pharmaceutical compositions useful in the above-referred methods of prevention and/or treatment, comprising as an active ingredient a partial inhibitor of factor VIII, in admixture with a pharmaceutically acceptable carrier. The invention also relates to the use of a partial inhibitor of factor VIII for the manufacture of a medicine for the prevention and/or treatment of the above-referred pathologies in mammals. Within the said pharmaceutical compositions, the partial inhibitor of factor VIII is preferably present in an anti-thrombin and/or activated protein C and/or tissue factor pathway inhibitor plasma level restoring amount. Additionally, the pharmaceutical compositions of this invention may further comprise a therapeutically effective amount of an anti-thrombotic agent such as heparin. In the various above-mentioned aspects of the present invention, the partial inhibitor of factor VIII may be a ligand, preferably other than a polyclonal antibody, more preferably a monoclonal antibody or antigen-binding fragment thereof, able to only partially (i.e. preferably at least 25% and at most 99%) inactivate factor VIII or a complex involving factor VIII when the said ligand is in a physiological excess by binding to a site of factor VIII or the said complex.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

5   Figure 1 shows producing human monoclonal antibodies derived from a hemophilia A patient, expressed in the form of IgG antibody binding to factor VIII in ELISA.
Figure 2 shows inhibition of factor VIII activity by the monoclonal antibody BO2C11.
Figure 3 shows inhibition of factor VIII activity by the monoclonal antibody produced from the cell line KRIX 1.
Figure 4 shows inhibition of binding of activated factor VIII on phosphatidyl-L-serine by the monoclonal antibody
10   produced from the cell line KRIX 1.
Figure 5 shows the influence of certain polyclonal antibodies on the dissociation of activated factor VIII from von Willebrand factor.
Figure 6 shows partial inhibition of thrombin by the monoclonal antibody produced from the cell line KRIX 1.
Figure 7 shows plasma concentrations of plasminogen activation inhibitor type-I in wild-type C57B1/6 mice and in
15   factor VIII knock-out mice after injection of lipopolysaccharide.
Figure 8 shows plasma concentrations of α_2-antiplasmin in wild-type C57B1/6 mice and in factor VIII knock-out mice after injection of lipopolysaccharide.
Figure 9 shows plasma concentrations of fibrinogen in wild-type C57B1/6 mice and in factor VIII knock-out mice after injection of lipopolysaccharide.
20   Figure 10 shows the amino-acid sequence SEQ.ID.No.2 (lower lines) and the nucleotide sequence SEQ.ID.No.1 (upper lines) for the variable regions V_H of the heavy chains of the human monoclonal antibodies BO2C11. Also shown are the three complementarity determining regions of each chain which are each an individual polypeptide ligand in accordance with an individual embodiment of the present invention.
Figure 11 shows the amino-acid sequence SEQ.ID.No.4 (lower lines) and the nucleotide sequence SEQ.ID.No.3
25   (upper lines) for the variable regions V_L of the light chains of the human monoclonal antibodies BO2C11. Also shown are the three complementarity determining regions of each chain which are each an individual polypeptide ligand in accordance with an individual embodiment of the present invention.
Figure 12 shows the amino-acid sequence SEQ.ID.No.6 (lower lines) and the nucleotide sequence SEQ.ID.No.5 (upper lines) for the variable regions V_H of the heavy chains of the KRIX 1 monoclonal antibodies. Also shown are
30   the three complementarity determining regions of each chain which are each an individual polypeptide ligand in accordance with an individual embodiment of the present invention.
Figure 13 shows the amino-acid sequence SEQ.ID.No.8 (lower lines) and the nucleotide sequence SEQ.ID.No.7 (upper lines) for the variable regions V_L of the light chains of the KRIX 1 monoclonal antibodies. Also shown are the three complementarity determining regions of each chain which are each an individual polypeptide ligand in
35   accordance with an individual embodiment of the present invention.

DEFINITIONS

[0014]   The term "ligand" is used herein with the meaning given at page 127 of The Molecular Biology of the Cell
40   (1983), Garland Publishing Inc., New-York, i.e. a molecule which is able to effectively interact with a protein through the simultaneous formation of a number of weak bonds between them.
[0015]   The term "antibody" as used herein refers to intact molecules which are capable of binding to the epitope determinant of factor VIII or the relevant domain of factor VIII, The term "fragment" refers to antigen-binding fragments, such as Fab, Fab', F(ab')$_2$, Fv and the like, of such antibodies.
45   **[0016]**   "Humanized antibody" as used herein refers to antibody molecules in which amino-acids have been replaced in the non-antigen binding regions in order to more closely look like a human antibody. "Reshaped human antibody" or "Human hybrid antibody" refers to a human antibody in which amino acids in the antigen binding regions of a human antibody have been replaced with sequences in accordance with the present invention, e.g. CDR's, or other parts of variable regions which have been derived from the repertoire of human antibodies.
50   **[0017]**   The term "homology" or "homologous" as used herein with reference to ligands in accordance with the present invention (such as antibodies) refers to a molecule which will compete with or inhibit binding of one of the said ligands to the target site. The binding should be specific, i.e. the binding of the alternative molecule should be as specific to the site as the ligand in accordance with the present invention. Where the said ligands include amino-acid sequences, then, homology should include having at least 80%, more preferably 90% and most preferably 95% amino acid se-
55   quence identity with the relevant ligand.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Factor VIII is a protein providing coagulant cofactor activity and is one of human clotting factors with a rather high molecular weight (265,000) and a very low normal plasma concentration (0.0007 micromol./litre). With its 2,332 amino-acid residues, factor VIII is one of the longest known polypeptide chains and is synthesized in the liver, the spleen and the placenta. Its gene has been shown to include 186,000 nucleotides.

[0019] Factor VIII circulates as inactive plasma protein. Factors V and VIII are homologous proteins sharing a common structural configuration of triplicated A domains and duplicated C domains with structurally divergent B domains connecting the A2 and A3 domains. Factor VIII circulates in a multiplicity of fragmented species in a tightly associated complex with von Willebrand factor at a concentration of 1 nmol/L. Factor VIII activation occurs by a cleavage between the A1 and A2 domains, resulting in the unstable heterotrimeric factor VIIIa molecule. Factor VIIIa binds tightly to membranes that contain acidic phospholipids. Factor VIII contains a phospholipid binding site in the C2 domain, between amino-acids 2302 and 2332, according to Arai et al. in *J.Clin.Invest.* (1989) 83:1978. Within the same factor VIII region, there is also a von Willebrand factor binding site acting in conjunction with amino-acid residues 1645-1689 in the A3 domain according to Shima et al. in *Throm.Haemost.* (1993) 69:240 and *J. Biol. Chem.* (1994)269:11601.

[0020] Lack or insufficient function of factor VIII results in haemophilia A. Patients with no factor VIII (severe form of the disease) have spontaneous bleedings in joints and soft tissues. In the mild form of the disease, bleedings occur only after trauma.

[0021] Inhibiting the function of factor VIII would therefore lead to spontaneous bleeding unless the said function is only partially inhibited. Taking this into account, the present inventors have developed specific anti-factor VIII monoclonal antibodies that inhibit factor VIII co-factor activity only to a limited extent.

[0022] Fully human, as well as humanized, monoclonal antibodies with high affinity for factor VIII are provided in accordance with the present invention, which exhibit an only partial inhibition of the function of factor VIII, independently of the dosage used, thereby preventing the risk of overdosing. These antibodies are used in the methods and pharmaceutical compositions of the invention, as further explained herein-below. Antibodies are unique reagents since they offer exquisite specificity for the determinant that they recognize. Anti-factor VIII antibodies bind to factor VIII but not to other, even homologue, proteins. Because of the low plasma concentration of factor VIII, only limited amounts of inhibiting antibodies are required to neutralize all factor VIII molecules. Besides, such antibodies have about three weeks in human beings, which advantageously allows to increase intervals between their administration to a mammal in need thereof..

[0023] The present invention relates to a general concept of only partially inactivating factor VIII by selecting certain ligands, such as human or humanized monoclonal antibodies or fragments or homologues thereof, and using them in methods and therapeutic compositions for preventing and/or treating systemic inflammatory response syndrome (SIRS) and/or sepsis and/or septic shock as well as thrombus formation in the microvasculature and/or disseminated intravascular coagulation in mammals, in particular in humans. These ligands and compositions have the advantageous property that the inactivation of the factor is only partial even when the ligand is in a molar excess. This means that even though the ligand is used in an amount which might be expected to inactivate completely the targeted factor, the inactivation is still incomplete.

[0024] The present invention provides a particular cell line producing human monoclonal antibodies which are reactive with human factor VIII and more specifically have the capacity of inactivating the co-factor activity of human factor VIII by interfering with proteolytic cleavage site or von Willebrand factor or tenase complex reaction or by inducing a three-dimensional conformational change in factor VIII, in particular by targeting a domain of factor VIII and by recognizing epitopes located in the said domain. One preferred domain is the C1 domain of factor VIII but the present invention is not limited thereto. A site on the C2 domain of factor VIII may also be partially inhibited. The present invention also includes ligands other than polyclonal antibodies, in particular monoclonal antibodies, which reduce the release rate of factor VIII from von Willebrand factor. These monoclonal antibodies specifically target factor VIII when bound to von Willebrand factor and hence target an epitope associated with the complex of factor VIII and von Willebrand factor. The present invention also provides fragments of any of the above monoclonal antibodies such as Fab, Fab', F(ab')$_2$, scFv, CDR's, single variable domains as well as homologues and combinations thereof. More particularly, these monoclonal antibodies and fragments may target a domain of factor VIII, in particular the C1 domain of factor VIII. They may also partially inhibit a site on the C2 domain of factor VIII. They may also target an epitope associated with the complex of von Willebrand factor and factor VIII. An aspect of the present invention is therefore to provide a new use of ligands, other than polyclonal antibodies, which bind to a first site (e.g. in the C1 domain of factor VIII) remote from a functional second site (e.g. the site in the C2 domain of factor VIII which is responsible for binding phospholipids) in such a way that the function of the second site is only partially impaired even when the ligand is in a molar and therapeutic excess.

[0025] The cell line named KRIX 1 producing monoclonal antibodies as used in the present invention was deposited with the BCCM™/LMBP (Belgian Co-ordinated Collections of Microorganisms/Plasmid Collection Laboratorium voor

Moleculaire Biologie, University of Ghent K.L. Ledeganckstraat 35, B-9000 Ghent, BE under accession number LMBP 5089CB on July 1,1999.

[0026] The present invention further provides cell lines producing human monoclonal antibodies having a reactivity substantially similar to that of the human monoclonal antibodies obtained from the above-mentioned deposited cell line, as well as the human monoclonal antibodies obtainable from these further cell lines.

[0027] The present invention further provides reshaped human monoclonal antibodies or human hybrid monoclonal antibodies against factor VIII, which bind to and only partially inactivate factor VIII or a complex including factor VIII and which comprise only elements derived from the repertoire of human antibodies. By human hybrid monoclonal antibodies it is meant a hybrid antibody constructed from a human antibody and from variable regions in accordance with the present invention. Conventionally in the art, until now it has only been possible to obtain antibodies against factor VIII derived from animals, e.g. mice, or to construct chimeric antibodies from human antibodies with the variable portions derived from mice antibodies.

[0028] The present invention also provides a new use of ligands, other than polyclonal antibodies, having the capacity of only partially inactivating factor VIII or a complex including factor VIII, by binding to a site of the said factor or complex, the said only partial inactivation also taking place when the ligand of the invention is in a molar excess with respect to the said factor. The site to which the ligand binds may or may not be directly or substantially involved in a physiological interaction of the said factor or complex. For instance, the ligand may bind to a site which is at a predetermined distance away from a physiologically functional site of the said factor. By partial inactivation, herein we mean an at most 99% inactivation, preferably an at most 95% inactivation, as determined by a suitable test method such as for instance the chromogenic assay available from Coatest™, Kabi Vitrum, Brussels (Belgium) or from Chromogenix AB, Mölndal (Sweden). On the other hand, in order to provide therapeutic usefulness, inactivation of factor VIII should be at least about 25%, preferably at least 60% and more preferably at least about 70%, as determined by the same test method as above. The extent of factor VIII inhibition or inactivation may vary from one patient to another, depending on the acuteness of the systemic inflammatory response syndrome SIRS and of its causality factor.

[0029] It will be appreciated that the inhibitors having partial inactivating capacity in accordance with the present invention operate in a different way from the mechanism conventionally ascribed to type II antibodies against factor VIII. One conventional mechanism is that of competition with another factor, e.g. von Willebrand factor. The kinetics of a competition mechanism means that if the one species is at a high concentration compared with the other (e.g. in a molar excess), the inhibition is effectively complete. In contrast, the inhibitors of the present invention reach a plateau effect in the inactivation of factor VIII, which is substantially independent of the excess of the inhibitor. The other conventional mechanism ascribed to type II antibodies is that of low affinity, in which case an excess will drive the reaction to complete inhibition as well.

[0030] The inhibitors useful in this invention may be human monoclonal antibodies obtainable from the deposited cell line KRIX 1, preferably being of class IgG, and which have the capacity of only partially inactivating the co-factor activity of factor VIII. More specifically the invention relates, in a preferred embodiment, to human monoclonal antibodies from such origin which are able to recognize epitopes located in the C1 domain of factor VIII. Although the inventors do not wish to be bound to a single explanation or theory, it is believed that the binding of such human monoclonal antibodies results in partial impairment of the binding of activated factor VIII to phospholipids, a necessary step for cofactor activity expression.

[0031] The present invention further provides a new use of monoclonal antibodies having substantially the same characteristics as above disclosed and being produced by on purpose immunization in animals, preferably in mouse, for instance by injecting human factor VIII in mice and then fusing the spleen lymphocytes with a mouse myeloma cell line, followed by identifying and cloning the cell cultures producing anti-factor VIII antibodies. The monoclonal antibodies produced in animals are then humanized, for instance by associating the binding complementarity determining region ("CDR") from the non-human monoclonal antibody with human framework regions - in particular the constant C region of human gene - such as disclosed by Jones et al. in *Nature* (1986) 321:522 or Riechmann in *Nature* (1988) 332:323.

[0032] The present invention also provides a new use of fragments and derivatives, in particular complementarity determining regions ("CDR's") of the above monoclonal anti-factor VIII antibodies as well as homologues thereof. For instance, the invention provides antigen-binding fragments Fab, Fab' and $F(ab')_2$ generated by proteolytic digestion of the said monoclonal antibodies while using methods well known in the art such as described by Stanworth et al., *Handbook of Experimental Immunology (1978),* vol.1 chapter 8 (Blackwell Scientific Publications). Such fragments, which contain the antibody binding site, have lost a number of properties of the parent antibody, such as complement activation or capacity to bind to Fc gamma receptors. The present invention also includes single chain fragment variables (scFv), single variable domain fragments of the antibodies and combination of these fragments and of the above mentioned fragments.

[0033] The invention also provides a new use of soluble or membrane-anchored single-chain variable parts of the above monoclonal antibodies and a method for their obtention as follows. The DNA sequences of the variable parts of human heavy and light chains are amplified in separated reactions and cloned. A fifteen amino-acid linker sequence,

for instance (Gly4 Ser)3, is inserted between VH and VL by a two-steps polymerase chain reaction (PCR), for instance according to Dieffenbach and Dveksler, "PCR Primer, a laboratory manual" (1995), Cold Spring Harbour Press, Plainview, NY, USA. The resulting fragment is then inserted into a suitable vector for expression of single chain fragment variable (scFv) as soluble or phage-displayed polypeptide. This can be achieved by methods well known to those skilled in the art, such as described by Gilliland et al., *Tissue Antigens* (1996) 47:1-20. The present invention also includes uses of a ligand comprising peptides representative of hypervariable regions of a monoclonal antibody which can be obtained by synthesis using an applied biosystem synthesizer, for instance a polypeptide synthesizer such as model 9050 available from Milligen (USA) or a model from a related technology, which alone or in combination with other or similar hypervariable regions will exert properties similar to that of the parent antibody.

[0034]   The invention further provides a pharmaceutical composition for the prevention or treatment of systemic inflammatory response syndrome and/or sepsis and/or septic shock and/or thrombus formation in the microvasculature and/or disseminated intravascular coagulation in mammals, comprising as an active ingredient a ligand, preferably other than a polyclonal antibody, more preferably a human monoclonal antibody such as disclosed hereinabove, in admixture with one or more pharmaceutically acceptable carriers. Most preferably the said monoclonal antibody is a human monoclonal antibody, or a fragment or a homologue thereof, obtainable from the cell line KRIX 1 deposited with the Belgian Co-ordinated Collections of Micro-organisms under accession number LMBP 5089CB. The degree of homology with the said monoclonal antibody is preferably at least 80%, more preferably 90% and most preferably 95%, and the homology is preferably particularly in respect to the complementarity determining regions of the antibody. A ligand as used in accordance with the present invention may also include a synthetic polypeptide of equivalent potency. The pharmaceutical composition of the present invention should comprise a therapeutically effective amount of the said above active ingredient, such as indicated hereinafter in respect to the method of treatment or prevention.

[0035]   The pharmaceutical composition of the present invention may further comprise, namely in view of a so-called combined treatment, a therapeutically effective amount of one or more anti-thrombotic agents. Such agents, as well as their usual dosage depending on the class to which they belong, are well known to those skilled in the art. Among numerous examples of such agents which may be included in the pharmaceutical compositions of the invention, the following non-limiting list may be particularly cited: heparin and low molecular weight heparin, anti-thrombin, heparinoids (such as danaparoid or dermatan sulphate), aprotinin-derived analogues, thrombomodulin, APC, defibrotide, TFPI, monoclonal antibodies against protease-activated receptors (PAR-1, PAR-3) and the like.

[0036]   Suitable pharmaceutical carriers for use in the pharmaceutical compositions of the invention are described for instance in Remington's Pharmaceutical Sciences 16th ed. (1980) and their formulation is well known to those skilled in the art. They include any and all solvents, dispersion media, coatings, antibacterial and antifungal agents (for example phenol, sorbic acid, chlorobutanol), isotonic agents (such as sugars or sodium chloride) and the like. Additional ingredients may be included in order to control the duration of action of the monoclonal antibody active ingredient in the composition. Control release compositions may thus be achieved by selecting appropriate polymer carriers such as for example polyesters, polyamino acids, polyvinyl pyrrolidone, ethylenevinyl acetate copolymers, methylcellulose, carboxymethylcellulose, protamine sulfate and the like. The rate of drug release and duration of action may also be controlled by incorporating the monoclonal antibody active ingredient into particles, e.g. microcapsules, of a polymeric substance such as hydrogels, polylactic acid, hydroxymethylcellulose, polymethyl methacrylate and the other above-described polymers. Such methods include colloid drug delivery systems like liposomes, microspheres, microemulsions, nanoparticles, nanocapsules and so on. Depending on the route of administration, the pharmaceutical composition comprising the active ingredient may require protective coatings. The pharmaceutical form suitable for injection use include sterile aqueous solutions or dispersions and sterile powders for the extemporaneous preparation thereof. Typical carriers therefore include biocompatible aqueous buffers, ethanol, glycerol, propylene glycol, polyethylene glycol and mixtures thereof.

[0037]   The present invention also provides the use of a partial inhibitor of factor VIII such as a monoclonal antibody (as disclosed herein-above) for the manufacture of a medicament or medicine for preventing and/or treating systemic inflammatory response syndrome and/or sepsis and/or septic shock as well as thrombus formation in the microvasculature and/or disseminated intravascular coagulation in mammals, preferably in humans. The said partial inhibitor of factor VIII may be provided to the mammal in need of such prevention and/or treatment by any means well known to the person skilled in the art, i.e. preferably subcutaneously, intramuscularly, intradermally, intravenously, intra-arterially, parenterally or by catheterization. According to the present invention, the partial inhibitor of factor VIII may also be used for the manufacture of a medicament in conjunction or association with another medicament, for instance an anti-thrombotic agent such as disclosed hereinabove under the heading of pharmaceutical compositions.

[0038]   The present invention further provides a method of treatment and/or prevention of blood circulation disorders following a systemic infection with gram (-) microorganisms in a mammal, preferably a human, comprising administering to a mammal in need of such treatment or prevention a therapeutically effective amount of a partial inhibitor of factor VIII, other than a polyclonal antibody, such as a monoclonal antibody as disclosed herein-above. Preferably the said partial inhibitor of factor VIII is a human or humanized monoclonal antibody obtainable from cell line KRIX 1 deposited

with the Belgian Co-ordinated Collections of Micro-organisms under accession number LMBP 5089CB or an antigen-binding fragment Fab, Fab' or F(ab')$_2$, a complementarity determining region (CDR), a soluble or membrane-anchored single-chain variable part (scFv), a single variable domain or a derivative or combination of any of these elements.

[0039]   A therapeutically effective amount as used herein means from about 1 microgram to about 5 milligrams per kilogram of body weight, more preferably from about 10 micrograms to about 1 milligram per kilogram of body weight of the mammal to be treated. More generally, the therapeutically effective amount may herein be defined as an anti-thrombin and/or activated protein C and/or tissue factor pathway inhibitor plasma level restoring amount. Such plasma levels may be easily and directly measured by the person skilled in the art by using methods such as disclosed in Laboratory Haematology (1989), ed. Chanarin, Churchill Livingstone, and in Laboratory techniques in Thrombosis, a manual (2nd revised edition of ECAT assay procedures, Eds Jespersen et al., Kluwer Academic Publishers (1999). It will be appreciated that, in view of the long half-life time of most IgG human antibodies, the partial inhibitors of the present invention being monoclonal antibodies of the said class will provide, in a majority of cases, an efficient prevention and/or treatment with a single administration.

[0040]   As preferred embodiments of the said disorders to be prevented or treated according to the invention may be cited: systemic inflammatory response syndrome (SIRS), sepsis, septic shock, thrombus formation in the microvasculature, disseminated intravascular coagulation (DIC), septicemia and the like. In a most preferred method of treatment, the patient is provided with a bolus (intravenously injected) at a dosage determined by the ordinary skilled physician depending on criteria establishing the particular patient's clinical condition.

[0041]   The method of treatment and/or prevention according to the invention may include further treatment or prevention of the same pathologic condition by administering, preferably by sequentially administering, to the patient a therapeutically effective amount of one or more anti-thrombotic agents such as disclosed hereinabove under the heading of pharmaceutical compositions. Sequentially, as used herein, means that the partial inhibitor of thrombin formation, such as the partial inhibitor of factor VIII of the present invention, and the known anti-thrombotic agent are administered to the patient sequentially but not simultaneously. More preferably, the partial inhibitor of factor VIII of the present invention is administered in the first place and the anti-thrombotic agent is administered afterwards.

[0042]   The partial inhibitors of factor VIII used in the present invention show the following advantages:

-   they efficiently but only partially inhibit the co-factor activity of factor VIII, even when used in a more than 100-fold excess, i.e. they achieve a plateau effect in the inactivation of factor VIII, thereby avoiding the risk of overdosing the patient.
-   human IgG antibodies exhibit a prolonged half-life time of three weeks (except for IgG3 which is one week), thus providing very stable plasma levels of the therapeutically active agent and allowing for a drastic reduction in the frequence of administration. Further, the use of human antibodies, fragments or homologues thereof, carries a minimal risk of inducing an immune response in the patient.
-   they inhibit the function of FVIII to an extent sufficient to reduce, or partially inhibit, the formation of thrombin. Reduction, but not complete suppression, of the formation of thrombin prevents the development of disseminated intravascular coagulation (DIC) while allowing normal clot formation. Preventing DIC maintains normal organ perfusion and avoids organ dysfunction and failure.
-   keeping the formation of thrombin under control reduces activation of the compensatory anti-inflammatory response. Thus, activated protein C is generated by direct thrombin cleavage and the effect of tissue factor pathway inhibitor is dependent on the presence of activated factor X, the activation of which is directly dependent on factor VIII co-factor activity. Limited depletion of circulating anti-thrombin (AT), which directly combines with thrombin, also occurs. In other words, both the pro-inflammatory and anti-inflammatory compensatory responses are maintained under control by regulating the rate of formation of thrombin.

[0043]   Moreover, the maintenance of significant levels of physiological anti-thrombotic factors such as AT offers the possiblity of a combined therapy with the partial inhibitors of factor VIII used in the present invention. For instance, heparin exerts its major activity as anti-thrombotic agent by combining to AT and dramatically increases the capacity of the latter to inhibit thrombin. Therefore, heparin administration together with the therapeutically active compound of this invention helps in delicately tuning the patient coagulation state.

[0044]   The persistance of significant anti-factor VIII antibody levels in circulation after the acute phase of the SIRS should not deter from its use. Since the antibodies used in this invention only partially neutralize factor VIII, there is no inherent risk of spontaneous bleeding. To the contrary, persistant stable anti-thrombotic prevention is regarded as beneficial in patients kept under partial immobilization.

[0045]   In most cases, a single administration of the partial inhibitor of factor VIII should be sufficient in view of the half-life of such human antibodies. However, under particular circumstances associated with the hypercatabolic state of sepsis, the administration may have to be repeated. In such cases, the absence of risk of overdosing (as explained hereinabove) precludes the need for monitoring factor VIII or antibody levels during treatment.

[0046] A further advantage of this invention is the lack of immunogenicity when the therapeutically active compound is of fully human origin. However, because in the treatment of SIRS according to the invention only one or a limited number of administrations should be sufficient, the development of an immune response to an exogeneous partial inhibitor of factor VIII such as an antibody is unlikely. The invention therefore extends to anti-factor VIII monoclonal antibodies of heterogeneous origin, such as antibodies or murine origin, and to partially humanized antibodies, provided that such antibodies exhibit the same characteristics of only partial inactivation of factor VIII.

[0047] The present invention is further described by the following examples which are provided without limiting intention and only for illustrative purposes.

EXAMPLE 1 - production of monoclonal antibodies derived from hemophilia A patients.

[0048] Human monoclonal antibodies of the desired specificity and characteristics are produced by transformation of B lymphocytes obtained from the peripheral blood of patients suffering from hemophilia A or acquired hemophilia. The method of selecting patients is an embodiment of the present invention. In order to elicit a more specific immunological response, patients are sought who have an impaired function of a physiologically active protein, e.g. factor VIII. By "impaired" is meant that some residual function is available but that this is less than is known for the wild-type of the same protein. A comparison between the self-protein and the wild-type protein should exhibit a difference in the two proteins, preferably in a region or domain which is of interest. The difference may be a deletion or a substitution of one or more amino acids with others. The patients are then administered enough of the wild-type protein to elicit an immunological response. Then, B-lymphocytes are extracted from the patients and selected based on the production of antibodies which have desirable properties. Although reference is made to "patients" above, the method in accordance with this embodiment may be applied generally to mammals. The above procedure results in a greater chance of obtaining antibodies which target the domain containing the defect.

[0049] B cells are transformed by infection with the Epstein-Barr virus and activation of surface antigens using techniques well known by those skilled in the art. Cell supernatants containing appropriate antibodies are identified by a specific assay procedure such as described in more details hereinbelow.

[0050] Thus, antibodies towards factor VIII are identified by reacting the supernatant with polystyrene microtitration plates coated with factor VIII or with factor VIII/von Willebrand factor complexes. The binding of specific antibodies is detected by addition of a non human IgG reagent coupled to an enzyme. Addition of an enzyme substrate which is converted to a colored compound in the presence of the enzyme allows the detection of specific antibodies. Such methods referred to as enzyme-linked immunoassays (ELISA) are well known to those skilled in the art and described in details e.g. in *Current Protocols in Immunology*, chapter 2, John Wiley & Sons (1994).

[0051] More specifically in the present case, the binding of anti-factor VIII IgG antibodies was detected by addition of a horseradish peroxidase labeled mouse monoclonal antibody specific for human Fcγ. The IgG subclass of the anti-factor VIII antibody was detected in ELISA, as presented in figure 1. The inhibition of factor VIII functional activity was tested in a functional coagulation assay as follows. Equal volume of the cell culture supernatant and of a pool of normal plasma were incubated for two hours at 37°C and the residual factor VIII activity measured thereafter. Those antibodies which significantly inhibit factor VIII activity are shown with an asterisk in figure 1.

[0052] B cells (such as BO 2C11) producing anti-factor VIII antibodies are then expanded and cloned by limiting dilution as described for instance in *Current Protocols in Immunology* (see supra). Anti-factor VIII antibodies having the capacity to inhibit the pro-coagulant activity of factor VIII are identified using a chromogenic assay kit such as a factor VIII chromogenic assay commercially available either from Dade, Düdingen (Germany) or Coatest™ from Kabi Vitrum, Brussels (Belgium) or Chromogenix AB, Mölndal (Sweden) (see figure 2). Equal volumes of monoclonal antibodies BO 2C11 and a pool of normal blood plasma were incubated for 2 hours at 37°C. BO 2C11 concentrations before mixing are shown on the X axis. The reduction of factor VIII activity was measured in a coagulation assay and was expressed as a percentage of the activity obtained in the absence of antibody. The residual activity goes to zero asymptotically (complete inhibition).

[0053] Antibodies which inhibit factor VIII function with sufficient affinity but do not inhibit factor VIII pro-coagulant activity completely, even when used in large antibody excess, were selected in a further embodiment of the present invention. A representative example of such an antibody is provided in figure 3 where equal volumes of KRIX 1 and of recombinant factor VIII or of normal plasma being incubated for two hours at 37°C and concentrations (expressed in μg/ml) of KRIX 1 before mixing with plasma being as indicated, the residual factor VIII activity was measured using the above-mentioned chromogenic assay. Figure 3 interestingly shows about 60 % factor VIII inhibition at a concentration of 0.1 μg/ml and more interestingly an asymptotic factor VIII inhibition of about 80% in the whole range of concentrations from 0.5 to 10 μg/ml.

[0054] The thus selected antibodies are then produced in bulk culture and purified by affinity chromatography using methods well known to those skilled in the art.

[0055] The details of a non-limiting preparation technique are as follows. Human recombinant factor VIII (specific

activity: 4000 IU/mg) was obtained from Hyland (Glendale, California); plasma-derived fVIII-vWf complex purified by ion exchange chromatography (specific activity ± 160 IU/mg protein; 15:1 vWf to fVIII weight ratio), and purified fVIII-depleted vWf (vWf to fVIII weight ratio 4800:1) were obtained from the Belgian Red Cross (Brussels, Belgium).

[0056] Peripheral blood samples were collected from donors suffering mild hemophilia and with inhibitors. The peripheral blood mononuclear cells (PBMC) were immortalized by Epstein-Barr virus infection concomitantly to the activation of surface antigens. 480 cell lines were screened by ELISA for production of antibodies towards factor VIII. One cell line, named KRIX 1, was successfully cloned by limiting dilution. Clonality was verified by RT-PCR amplification of mRNA coding for the V regions of the antibody heavy and light chains: a single sequence was obtained from 10 clones of PCR products. Purified antibodies were obtained by passage of KRIX 1 cell culture supernatant onto Protein-A Sepharose. An ELISA performed with IgG subclass- and light chain-specific antibodies identified KRIX-1 as an IgG4k.

[0057] Human monoclonal antibodies were purified by adsorption on immobilized Protein A (hi-Trap Protein A available from Pharmacia, Uppsala, Sweden). Fab fragments of human monoclonal antibody were prepared by papain digestion. 1 mg of a selected antibody was diluted to 500 µg/ml in phosphate buffer (40 mmol/L KH_2PO_4; 60 mM $Na_2HPO_4.2H2O$, 0.15M NaCl) containing 50 mmol/L L-cystein (Sigma), 1 mmol/L EDTA (Merck) and 10 µg papain (Sigma). The mixture was incubated for 3 hours at 37°C with continuous agitation. The reaction was stopped by addition of iodoacetamide to a final concentration of 75 mmol/L for 30 minutes at room temperature. The digested antibody was dialysed against phosphate-buffered saline (140 mmol/L NaCl, 67 mmol/L KCl, 20 mmol/L Na_2HPO_4, 4.4 mmol/L KH_2PO_4, pH 7.4). The undigested IgG and Fc fragments were then eliminated by passage over protein A sepharose (Hi Trap Protein A from Pharmacia). The Fab fragment was further purified by gel filtration chromatography on a Superdex 200 (Pharmacia).

[0058] Conventional methods were used for the detection of anti-factor VIII IgG antibodies, the determination of IgG subclass, and the evaluation of inhibition of factor VIII binding to vWf. For analyzing the inhibition of binding of rfVIII to a selected antibody by Fab and native antibody, Maxisorb polystyrene plates (Nunc) were coated for 2 hours with 50 µl of the antibody diluted to 5 µg/ml in glycine-buffered saline (20 mmol/L glycine, 34 mmol/L NaCl, pH 9.2). After washing, 50 µl of biotin-labeled rfVIII diluted to 1 µg/ml in Tris-casein (10 mmol/L tris(hydroxymethyl)-aminoethane, pH 7.3, containing 150 mmol/L NaCl and 0.5% casein) were mixed for 1 hour at 37°C with 50 µl of human IgG at various dilutions. A 50 µl aliquot of the mixture was added to the plates for 2 hours at room temperature. After washing, the binding of biotinylated rfVIII was detected by sequential addition of avidin-peroxydase and OPD.

[0059] rfVIII (final concentration 0.2 µg/mL) was incubated with human IgG antibody at different concentrations for 2 hours at 37°C and the residual factor VIII activity was assessed by a factor VIII chromogenic assay (e.g. Coatest™, see *supra*). Inhibition of plasma factor VIII activity was measured by the Bethesda method, in which a pool of normal plasma collected in buffered trisodium citrate was used as factor VIII source. Residual factor VIII activity was assessed by a chromogenic or by a one-stage clotting assay.

EXAMPLE 2 - Production of monoclonal antibodies by immunization in animals.

[0060] Alternatively, monoclonal antibodies having the same characteristics as disclosed in example 1 can be produced by on purpose immunization in animals. Thus, mice are injected with human factor VIII in Freund's adjuvant.

[0061] Monoclonal anti-human factor VIII antibodies are then obtained by fusion of spleen lymphocytes with a mouse myeloma cell line. Cell culture supernatants producing anti-factor VIII antibodies are identified and cloned by limiting dilution, using methods described in *Current Protocols in Immunology* (see supra). Further selection of inhibitors having the desired capacity to inhibit the pro-coagulant activity of factor VIII is carried out as described in example 1.

[0062] Monoclonal antibodies produced in mice are then humanized. Thus, sequences of the variable parts of mouse heavy and light chains are aligned with human immunoglobulin variable regions to identify human antibody with the greatest homology in framework regions. The DNA fragment encoding humanized variable regions are then synthesized by a PCR-based CDR (complementarity determining regions) grafting method as described for instance in Sato et al., *Cancer Research* (1993) 53:851-6. The final PCR product coding for the heavy chain variable part of the humanized antibody is digested and subcloned upstream of the human C gamma-1 gene in a first expression plasmid. The humanized light chain variable region of the final construction is inserted upstream of the C kappa gene in a second expression plasmid. The two constructions are then co-transfected into COS cells expression system.

EXAMPLE 3 - Characterization of anti-factor VIII antibodies.

[0063] Monoclonal antibodies of either human (example 1) or animal (example 2) origin are characterized using an assay system by which their capacity to inhibit the binding of factor VIII to phospholipids is evaluated. Thus, polystyrene microtitration plates are coated with phosphatidyl-L-serine. Soluble recombinant factor VIII at 2 µg/ml final concentration is mixed for 30 minutes at 37°C with various concentrations of the antibody under evaluation. The mixture is then rapidly activated with thrombin and added to phosphatidyl-L-serine coated plates. The said plates were then incubated

for two minutes at 21°C and the binding of factor VIII was detected by addition of the anti-factor VIII A1 domain mAbF14A2, for two minutes, followed by a two minute incubation with HRP-conjugated goat anti-mouse Fcγ. Results of this experiment are shown, for the monoclonal antibody produced from the cell line KRIX 1, in figure 4 wherein the average of activated factor VIII binding in the absence (closed symbols) or presence (open symbols) of the antibody, as well as the standard deviation of triplicates are indicated. Controls in the absence of factor VIII gave OD 490 lower than 0.05. Figure 4 thus clearly shows that the monoclonal antibody produced from cell line KRIX 1 inhibits significantly the binding of factor VIII to phospholipids but brings about incomplete inhibition even when added in large excess.

[0064]   To demonstrate that in absence of plasma, KRIX 1 did not recognize the mutated factor VIII light chain of the donor, DNA fragments encoding wild-type and mutated factor VIII light chains were synthesized. The corresponding proteins were expressed in reticulocyte lysates. The correct folding of native and mutated light chains was determined by immunoprecipitation with the human monoclonal antibody BO2C11, which recognizes a conformational epitope within the carboxy-terminal part of the factor VIII light chain. Immunoprecipitation experiments indicated that BO2C11 bound wild-type and Arg2150His light chains, whereas KRIX 1 captured exclusively the wild-type light chain. Prolonged exposure of SDS-PAGE gels to the autoradiography film failed to detect any significant binding of KRIX 1 to the mutated light chain. Control experiments showed no binding to assay reagents other than factor VIII or factor VIII fragments, and preincubation with soluble rfVIII prevented the binding to methionine-labeled factor VIII fragments, confirming the binding specificity.

[0065]   KRIX 1 did not recognize factor VIII in Western blotting indicating that the epitope recognized was conformational. Further epitope mapping was therefore performed with factor VIII fragments produced in reticulocyte lysates. Preliminary experiments had indicated that such an approach was efficient for the synthesis of factor VIII domains. The immunoprecipitation procedure using labeled factor VIII domains produced in reticulocyte lysate was validated by mapping the epitope recognized by the human monoclonal antibody BO2C11. A complete agreement was observed between the binding to factor VIII C2 deletion fragments produced in reticulocyte lysates and the binding to recombinant fragments produced in *E. coli* or COS cells. KRIX 1 bound to full-length light chain, to fragments corresponding to A3C1, C1C2 and the isolated C1 domain. In contrast, KRIX 1 did not bind to the C1 or C1C2 domains with the substitution Arg2150His, although in a control experiment, the Arg2150His C1C2 domain was bound by BO2C11 like its normal counterpart.

[0066]   A search was made for other mutations in the light chain which could alter the binding of KRIX 1. As shown in Table 1 below, KRIX 1 inhibited the activity of all mutated factor VIII molecules tested so far, except those carrying the mutation Arg2150His.

Table 1 -

inhibition of FVIII activity in mild hemophilia A patients' plasma.		
Factor VIII mutation	Factor VIII activity (IU/ml)	KRIX-1 Inhibition (%)
Arg1689Leu	0,04	>70
Arg1749His	0.39	>70
Gly1750Arg	0.38	>70
Ala1824Val	0.16	>70
Asp1825Gly	0.17	>70
His1961Tyr	0.24	>70
Arg1966Gln	0.08	>70
Met2010Ile	0.04	>70
Ser2011Asn	0.23	>70
Val2016Ala	0.05	>70
Asn2019ser	0.13	>70
Leu2052Phe	0.23	>70
Asp2074Gly	0.13	>70
Thr2086Ile	0.08	>70
Ile2098Ser	0.20	>70

Table 1 - (continued)

inhibition of FVIII activity in mild hemophilia A patients' plasma.		
Factor VIII mutation	Factor VIII activity (IU/ml)	KRIX-1 Inhibition (%)
Phe2101Leu	0.06	>70
Asn2129Ser	0.20	>70
Arg2150His	0.03	0
Pro2153Gln	0.02	65
Arg2159Leu	0.16	>70
Trp2229Cys	0.02	>70
Gln2246Arg	0.08	>70

[0067] In the use of KRIX 1 as a medicament to partially inhibit factor VIII, mild mutations of factor VIII will therefore not affect the effectiveness of the prophylactic or therapeutic treatment according to the invention.

[0068] KRIX 1 inhibited the binding of factor VIII to vWf in a dose-dependent manner. The concentration of KRIX 1 required to achieve 50% inhibition (IC_{50}) of factor VIII binding was 0.25 μg/mL and more than 95% inhibition was obtained with 20 μg/mL of KRIX 1. Fab fragments of KRIX 1 also inhibited factor VIII binding to vWf. However, on a molar basis 15 times more Fab than native KRIX 1 was required to inhibit 50% of factor VIII binding to vWf. Additional experiments were performed in order to exclude that KRIX 1 Fab fragments could possibly still contain intact or partially digested antibody. SDS-PAGE analysis of the Fab fragments purified by protein A adsorption and gel filtration chromatography showed a single band. The presence of trace amounts of Fcγ fragments remaining bound to Fab fragments was excluded in ELISA. Wells with insoluble factor VIII were incubated with native or Fab KRIX 1. Binding of both Fab and native KRIX 1 could be detected by addition of peroxydase labeled anti-k light chain IgG. By contrast, addition of peroxydase labeled anti-Fcγ IgG did not reveal any specific binding even when 100 μg/ml of the Fab preparation were incubated into the wells. By comparison, the addition 0.1 μg/ml of the native antibody gave rise to a significant binding. In ELISA, a 15-fold higher concentration of Fab than of native antibody was required to inhibit 50% of the binding of biotinylated KRIX 1 onto insoluble factor VIII, indicating that the Fab KRIX 1 fragment had a lower affinity for factor VIII than the native antibody. Accordingly, the requirement for higher concentrations of KRIX 1 Fab than of native antibody to inhibit factor VIII binding to vWf should be attributed to the reduced affinity of KRIX 1 Fab fragments for factor VIII.

[0069] In order to determine whether KRIX 1 was representative of the polyclonal antibodies from the donor, a competitive assay was used. The binding of biotinylated KRIX 1 to insoluble factor VIII was measured in presence of increasing concentrations of either KRIX 1, polyclonal IgG from the donor, or control polyclonal IgG. IgG from the donor dose-dependently inhibited KRIX 1 binding to factor VIII. Concentrations of KRIX 1 and IgG from the donor inhibiting 50% of biotinylated KRIX 1 on factor VIII were respectively 0.3 μg/ml and 170 μg/ml, whereas no inhibition was observed with the control IgG.

EXAMPLE 4 - production of monoclonal antibodies derived from hemophilia A patients and which bind to factor VIII and von Willebrand factor complex.

[0070] Alternatively, antibodies which reduce the release rate of factor VIII from von Willebrand factor are identified as follows. Polystyrene microtitration plates are coated with a specific antibody to von Willebrand factor (vWF). A solution of biotinylated recombinant factor VIII (0.5 μg/mL) complexed to vWF (5 μg/mL) is mixed with various concentrations of IgG from a donor (Figure 5 solid squares), e.g. the same patient as described above (from which KRIX 1 was derived), MoAb4H1D7, or of IgG from a non-hemophiliac subject (Figure 5 solid triangles). IgG at the indicated concentrations was added to microtitration plates coated with a mouse antibody, MoAb4H1D7 against vWF for an incubation of 2 hours at room temperature. After washing, factor VIII was activated by thrombin during two minutes at 37°C. Factor VIII bound to vWF was detected by addition of avidine peroxydase. Controls included the detection of bound biotinylated factor VIII in the absence of thrombin digestion (OD450=460+47.7SD) and of biotinylated recombinant factor VIII after thrombin digestion in the absence of antibody (OD450=160+16.OSD).

[0071] Results of these experiments for polyclonal antibodies are shown in figure 5, wherein the average values as well as the standard deviation of triplicates are indicated. Figure 5 thus clearly shows that a significantly higher proportion of activated factor VIII remains bound to the plate in the presence of increasing concentrations of the antibody, i.e. it demonstrates a reduction of the dissociation of activated factor VIII from vWF in the presence of an inhibitor antibody recognizing factor VIII bound to vWF. Monoclonal antibodies have been obtained from these polyclonal anti-

bodies in accordance with the methods described in this invention. These antibodies exhibit the "plateau" effect at molar excess as described above with respect to the KRIX 1 antibody, thus indicating that the present invention may be extended to monoclonal antibodies and fragments and derivatives thereof which bind to complexes.

EXAMPLE 5 - monoclonal antibodies derived from hemophilia A patients partially inhibit thrombin formation *in vitro.*

[0072]   Human monoclonal antibodies produced according to example 1 were tested *in vitro* against the rate of thrombin formation using whole blood. Thus, citrated whole blood was recalcified and shaken at 900 rpm at 37°C in 24-well cell suspension culture plates avoiding contact activation. Samples were then transferred at regular intervals to a solution containing ethylenediaminetetraacetic acid (EDTA) in order to stop further coagulation activation. Following centrifugation, thrombin formation was then determined by a method well known in the art, e.g. by measuring optical density using the chromogenic substrate S-2238. Results of these tests are provided in figure 6, wherein absorption (expressed in nm) measured by the said method is indicated as a function of time for the sample incubated with KRIX 1 derived antibodies (noted KRIX 1) and for the control incubated without such antibodies (noted CTRL). This figure thus clearly shows that the addition of 2.5 μg/ml of human monoclonal antibodies derived from the cell line KRIX 1 significantly reduces (by about 1/3) but does not abolish the rate of thrombin formation as compared to the control.

EXAMPLE 6 - *in vivo* reduction of thrombin formation by decreased levels of factor VIII.

[0073]   Injection of endotoxin elicits the production of pro-inflammatory cytokines among which IL-6 and TNF-α are important for their interactions with the coagulation system. Thus, IL-6 increases the production of tissue factor and, consequently, the generation of thrombin. It also increases the production of fibrinogen by an independent mechanism. TNF-α increases the levels of plasminogen activation inhibitor type I (PAI-1) and thereby reduces fibrinolysis.

[0074]   In order to show the effect of the presence of factor VIII on the latter reactions, groups of mice having the same genetic background (C57Bl/6) with either normal factor VIII concentrations or the corresponding factor VIII knock-out strain were compared.

[0075]   Three groups of six mice were constituted for each of the two strains. Mice were injected intraperitoneously with either 0.4 μg, 4 μg or 40 μg lipopolysaccharide (from E. coli serotype 0:111:B4) per 20 g of body weight. 90 minutes later, blood was taken by cardiac puncture in citrate buffer for evaluation of cytokine and coagulation factor levels. Plasma was obtained by centrifugation for 5 minutes at 5,000 rpm.

[0076]   First, in order to determine whether comparable inflammatory changes had been inflicted to mice in the two strains, the level of IL-6 was evaluated. No interstrain differences were seen for each of the three different doses of lipopolysaccharide.

[0077]   The extent to which the fibrinolytic pathway had been activated by a lipopolysaccharide injection of 40 μg per 20 g body weight was then evaluated by measuring concentrations of the two main pathway inactivators, namely PAI-1 and α_2-antiplasmin, using a sandwich-type ELISA with two specific monoclonal antibodies directed towards different sites of the molecule under evaluation. Figure 7 shows that the increase in PAI-1 concentration was similar in the two mouse strains, and figure 8 shows a similar behavior for α_2-antiplasmin. This indicates that the fibrinolytic activity was independent of the presence or the absence of factor VIII.

[0078]   The evolution of fibrinogen plasma concentrations was used as a reading of its conversion into fibrin. As shown in Figure 9, the level of fibrinogen decreased by 45% in the group of mice with normal factor VIII level, as compared to the corresponding factor VIII knockout strain.

[0079]   It is therefore concluded that, for an identical inflammatory trigger exemplified by increased IL-6 levels, and comparable activation of the fibrinolytic pathway, there was a significant reduction in fibrinogen degradation only in the presence of normal factor VIII concentrations. Lack or reduced levels of factor VIII therefore prevents the deposition of fibrin in the microvasculature, a key phenomenon in the systemic inflammatory syndrome leading to organ failure.

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Met Glu Thr Pro Ala Gln Leu Leu Phe Leu Leu Leu Leu Trp Leu Pro


1                5                        10                      15




gat acc acc gga gaa att gcg ttg acg cag tct cca ggc acc ctg tct

   96
Asp Thr Thr Gly Glu Ile Ala Leu Thr Gln Ser Pro Gly Thr Leu Ser


              20                   25                      30




ttg tct cca ggg gaa aga gcc acc ctc tcc tgc agg gcc agt cag agt

  144
Leu Ser Pro Gly Glu Arg Ala Thr Leu Ser Cys Arg Ala Ser Gln Ser


         35                   40                   45




ttt agc agc agc tac tta gcc tgg tat cag cag aaa cct ggc cag gct

  192
Phe Ser Ser Ser Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Gln Ala


         50                   55                   60
```

ccc agg ctc ctc atc tat ggt gca tcc acc agg gcc act ggc atc cca

240

Pro Arg Leu Leu Ile Tyr Gly Ala Ser Thr Arg Ala Thr Gly Ile Pro

65   70   75   80

gac agg ttc agt ggc agt ggg tct ggg aca gac ttc act ctc acc atc

288

Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile

85   90   95

agc aga ctg gag cct gaa gat ttt gca gtg tat tac tgt cag aag tat

336

Ser Arg Leu Glu Pro Glu Asp Phe Ala Val Tyr Tyr Cys Gln Lys Tyr

100   105   110

ggt acg tca gcg atc acc ttc ggg caa ggg aca cga ctg gag att aaa

384

Gly Thr Ser Ala Ile Thr Phe Gly Gln Gly Thr Arg Leu Glu Ile Lys

115   120   125

gga act gtg gct gca cca tct gtc ttc atc ttc ccg cca tct

426

Gly Thr Val Ala Ala Pro Ser Val Phe Ile Phe Pro Pro Ser

130   135   140

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<223>    complementary determining region number three

<400>    4
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Met Glu Thr Pro Ala Gln Leu Leu Phe Leu Leu Leu Leu Trp Leu Pro

1   5   10   15

Asp Thr Thr Gly Glu Ile Ala Leu Thr Gln Ser Pro Gly Thr Leu Ser

            20   25   30

Leu Ser Pro Gly Glu Arg Ala Thr Leu Ser Cys Arg Ala Ser Gln Ser

            35   40   45

Phe Ser Ser Ser Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Gln Ala

        50   55   60

Pro Arg Leu Leu Ile Tyr Gly Ala Ser Thr Arg Ala Thr Gly Ile Pro

65   70   75   80

Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile

```
                    85                      90                      95
```

Ser Arg Leu Glu Pro Glu Asp Phe Ala Val Tyr Tyr Cys Gln Lys Tyr

```
            100                     105                     110
```

Gly Thr Ser Ala Ile Thr Phe Gly Gln Gly Thr Arg Leu Glu Ile Lys

```
            115                     120                     125
```

Gly Thr Val Ala Ala Pro Ser Val Phe Ile Phe Pro Pro Ser

```
        130                     135                     140
```

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1   5   10   15

gcc cac tcc cag gtg caa ctg gtg caa tct ggg gct gag gtg aag aag
    96
Ala His Ser Gln Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys

            20   25   30

cct ggg gcc tca gtg aag gtc tcc tgc aag acc tct gga tac aac ttc
    144
Pro Gly Ala Ser Val Lys Val Ser Cys Lys Thr Ser Gly Tyr Asn Phe

        35   40   45

acc ggc tac tct gct tct gga cat atc ttc acc gcc tac tct gtg cac
    192
Thr Gly Tyr Ser Ala Ser Gly His Ile Phe Thr Ala Tyr Ser Val His

        50   55   60

tgg gtg cga cag gcc cct gga caa ggg ctt gag tgg atg gga agg atc
    240
Trp Val Arg Gln Ala Pro Gly Gln Gly Leu Glu Trp Met Gly Arg Ile

65   70   75   80

aac cct aac agt ggt gcc aca gac tat gca cat aaa ttt cag ggc agg

288

Asn Pro Asn Ser Gly Ala Thr Asp Tyr Ala His Lys Phe Gln Gly Arg

          85   90   95

gtc acc atg tcc agg gac acg tcc atc agc aca gcc tac atg gaa ctg

336

Val Thr Met Ser Arg Asp Thr Ser Ile Ser Thr Ala Tyr Met Glu Leu

         100   105   110

agc agg ctg aca tct gac gac acg gcc atg tat tac tgt gcg aga gcc

384

Ser Arg Leu Thr Ser Asp Asp Thr Ala Met Tyr Tyr Cys Ala Arg Ala

         115   120   125

gac aac tat ttc gat att gtg act ggc tat act tct cat tac ttt gac

432

Asp Asn Tyr Phe Asp Ile Val Thr Gly Tyr Thr Ser His Tyr Phe Asp

         130   135   140

tac tgg ggc cgg gga acc ctg gtc acc gtc tcc tca

468

Tyr Trp Gly Arg Gly Thr Leu Val Thr Val Ser Ser

145   150   155

```
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<213>   Homo sapiens

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<223>   complementary determining region number three

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Met Asp Trp Thr Trp Arg Ile Leu Phe Leu Val Ala Ala Ala Thr Gly

1   5   10   15

Ala His Ser Gln Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys

            20   25   30

Pro Gly Ala Ser Val Lys Val Ser Cys Lys Thr Ser Gly Tyr Asn Phe

        35   40   45

Thr Gly Tyr Ser Ala Ser Gly His Ile Phe Thr Ala Tyr Ser Val His

        50   55   60

Trp Val Arg Gln Ala Pro Gly Gln Gly Leu Glu Trp Met Gly Arg Ile

65   70   75   80

```
     Asn Pro Asn Ser Gly Ala Thr Asp Tyr Ala His Lys Phe Gln Gly Arg
                     85              90                  95


     Val Thr Met Ser Arg Asp Thr Ser Ile Ser Thr Ala Tyr Met Glu Leu
                 100             105                 110


     Ser Arg Leu Thr Ser Asp Asp Thr Ala Met Tyr Tyr Cys Ala Arg Ala
                 115             120                 125


     Asp Asn Tyr Phe Asp Ile Val Thr Gly Tyr Thr Ser His Tyr Phe Asp
             130             135                 140


     Tyr Trp Gly Arg Gly Thr Leu Val Thr Val Ser Ser
     145             150                 155


     <210>   7
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     <220>
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     <222>   (1)..(429)
     <223>


     <220>
     <221>   CDS
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     <223>   complementary determining region number one
```

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atg gaa acc cca gct cag ctt ctc ttc ctc ctg cta ctc tgg ctc cca

   48
Met Glu Thr Pro Ala Gln Leu Leu Phe Leu Leu Leu Leu Trp Leu Pro


1               5                       10                      15




gat acc acc gga gaa att gtg ttg acg cag ttc cca ggc acc ctg tct

   96
Asp Thr Thr Gly Glu Ile Val Leu Thr Gln Phe Pro Gly Thr Leu Ser


             20                      25                      30




ttg tct cca ggg gaa aga gcc acc ctc tcc tgc agg gcc agt cag agt

  144
Leu Ser Pro Gly Glu Arg Ala Thr Leu Ser Cys Arg Ala Ser Gln Ser


             35                      40                      45




gtt gcc agc gcc tac tta gcc tgg tac cag caa aaa cct ggc cag gct

  192
Val Ala Ser Ala Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Gln Ala


             50                      55                      60
```

ccc agg ctc ctc atc tat ggt gca tcc agt agg gcc acc gac atc cca
240
Pro Arg Leu Leu Ile Tyr Gly Ala Ser Ser Arg Ala Thr Asp Ile Pro

65   70   75   80

cac agg ttc agt ggc agt ggg tct ggg aca gac ttc act ctc acc atc
288
His Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile

                    85   90   95

agc aga ctg gag cct gaa gat ttt gca gtg tac tac tgt cag caa tat
336
Ser Arg Leu Glu Pro Glu Asp Phe Ala Val Tyr Tyr Cys Gln Gln Tyr

                    100   105   110

ggt acc tca gcc tta ctc act ttc ggc gga ggg acc aag gtg gag atc
384
Gly Thr Ser Ala Leu Leu Thr Phe Gly Gly Gly Thr Lys Val Glu Ile

                    115   120   125

aaa cga act gtg gct gca cca tct gtc ttc atc ttc ccg cca tct
429
Lys Arg Thr Val Ala Ala Pro Ser Val Phe Ile Phe Pro Pro Ser

                    130   135   140

```
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<400>   8

Met Glu Thr Pro Ala Gln Leu Leu Phe Leu Leu Leu Leu Trp Leu Pro

1               5                   10                  15


Asp Thr Thr Gly Glu Ile Val Leu Thr Gln Phe Pro Gly Thr Leu Ser

            20                  25                  30


Leu Ser Pro Gly Glu Arg Ala Thr Leu Ser Cys Arg Ala Ser Gln Ser

            35                  40                  45


Val Ala Ser Ala Tyr Leu Ala Trp Tyr Gln Gln Lys Pro Gly Gln Ala

        50                  55                  60


Pro Arg Leu Leu Ile Tyr Gly Ala Ser Ser Arg Ala Thr Asp Ile Pro

65                  70                  75                  80
```

```
His Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile
                 85                  90                  95


Ser Arg Leu Glu Pro Glu Asp Phe Ala Val Tyr Tyr Cys Gln Gln Tyr
                100                 105                 110


Gly Thr Ser Ala Leu Leu Thr Phe Gly Gly Gly Thr Lys Val Glu Ile
            115                 120                 125


Lys Arg Thr Val Ala Ala Pro Ser Val Phe Ile Phe Pro Pro Ser
    130                 135                 140
```

Claims

1. A pharmaceutical composition for the prevention and/or treatment of systemic inflammatory response syndrome and/or sepsis and/or septic shock and/or thrombus formation in the microvasculature and/or disseminated intra-vascular coagulation in mammals, comprising as an active ingredient a partial inhibitor of factor VIII, in admixture with a pharmaceutically acceptable carrier.

2. A pharmaceutical composition according to claim 1, wherein the partial inhibitor of factor VIII is a ligand able to only partially inactivate factor VIII or a complex involving factor VIII when the said ligand is in a physiological excess by binding to a site of factor VIII or the said complex.

3. A pharmaceutical composition according to claim 2, wherein the only partial inactivation, by the said active ingredient, of factor VIII or of a complex involving factor VIII is an at most 99% inactivation.

4. A pharmaceutical composition according to claim 2 or claim 3, wherein the only partial inactivation, by the said active ingredient, of factor VIII or of a complex involving factor VIII is an at least 25% inactivation.

5. A pharmaceutical composition according to any of claims 1 to 4, wherein the partial inhibitor of factor VIII is present in an anti-thrombin and/or activated protein C and/or tissue factor pathway inhibitor plasma level restoring amount.

6. A pharmaceutical composition according to any of claims 1 to 5, further comprising a therapeutically effective amount of an anti-thrombotic agent.

7. A pharmaceutical composition according to claim 6, wherein the anti-thrombotic agent is heparin.

8. A pharmaceutical composition according to any of claims 1 to 7, wherein the the partial inhibitor of factor VIII is a human monoclonal antibody obtainable from the cell line named KRIX 1 deposited with the Belgian Coordinated Collections of Micro-organisms under accession number LMBP 5089CB, or from a cell line producing human monoclonal antibodies having a reactivity identical to that of human monoclonal antibodies obtained from the cell line KRIX 1.

9. A pharmaceutical composition according to any of claims 1 to 8, wherein the the partial inhibitor of factor VIII is

able to recognize epitopes located in the C1 domain of factor VIII.

10. Use of a partial inhibitor of factor VIII for the manufacture of a medicine for the prevention and/or treatment of systemic inflammatory response syndrome and/or sepsis and/or septic shock and/or thrombus formation in the microvasculature and/or disseminated intravascular coagulation in mammals.

IgG antibody binding to FVIII in ELISA

BO 2A10	IgG4
BO 2C11	IgG4
BO 2F11	IgG4
BO 2G2	IgG4
BO 3E10	IgG2
BO 2D2	IgG4
BO 2F8	IgG4
BO 4H10	IgG1
BO 12D10	IgG1

Optical density

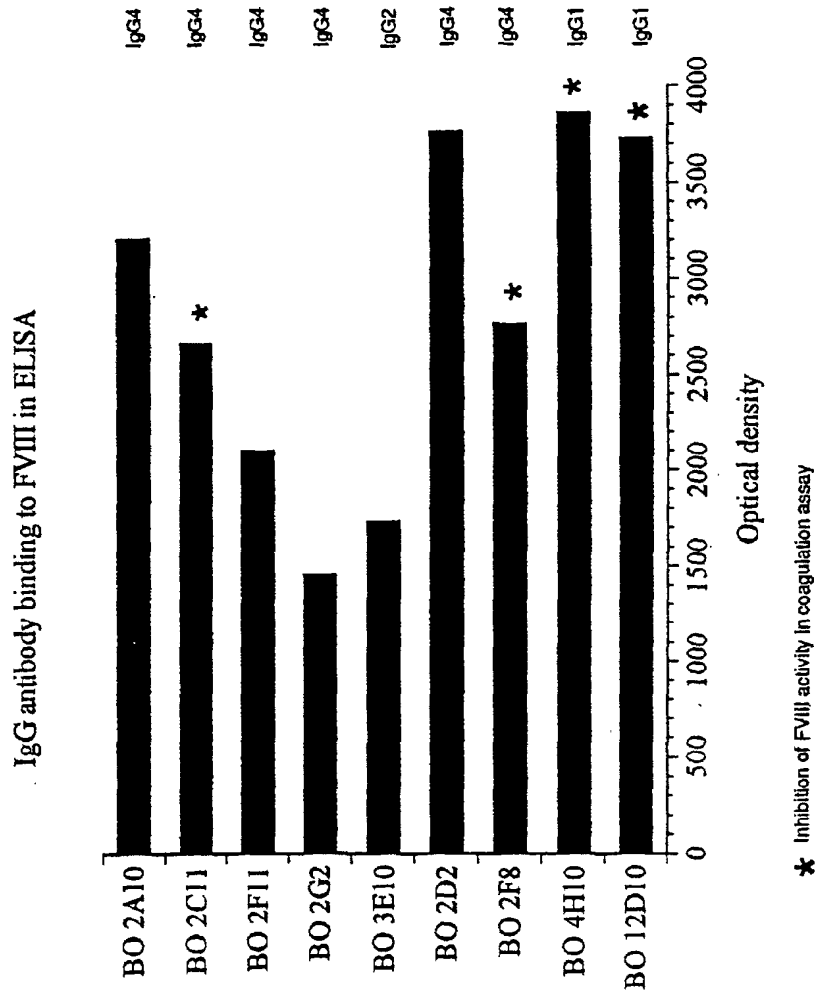0   500   1000   1500   2000   2500   3000   3500   4000
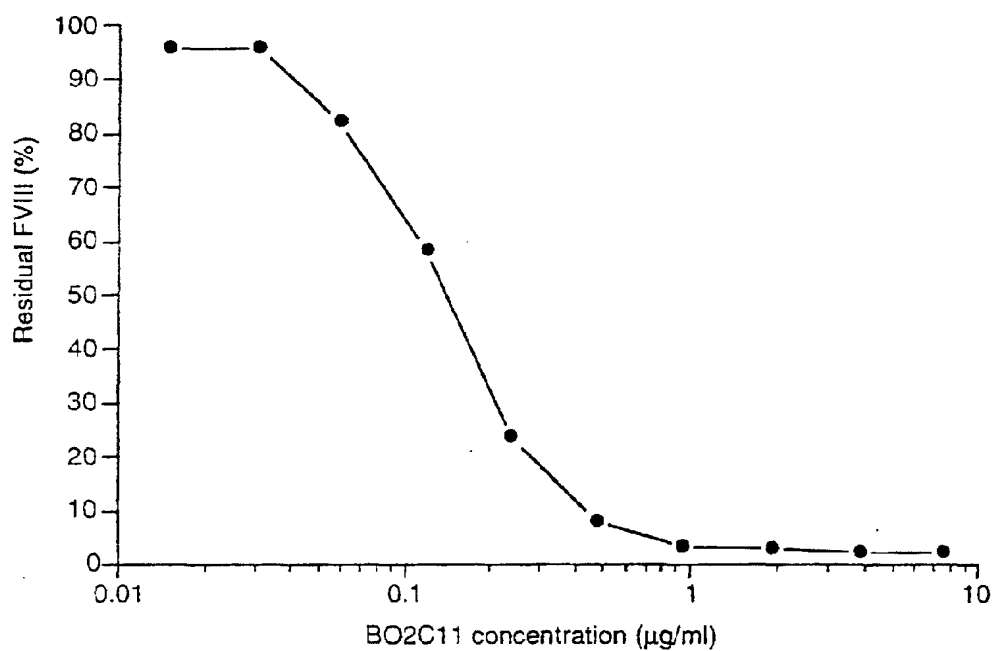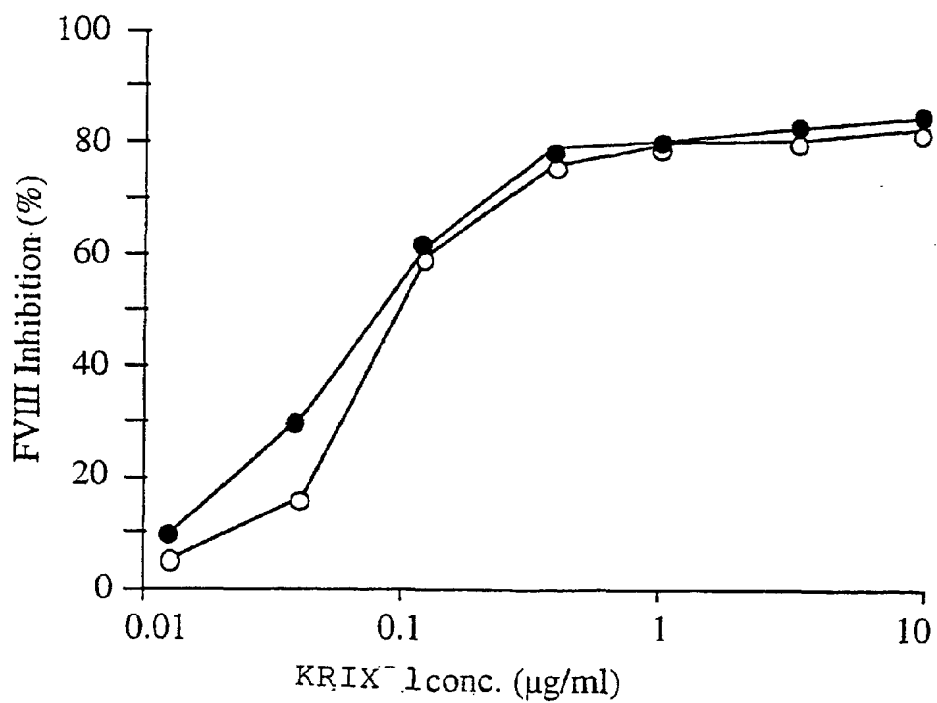
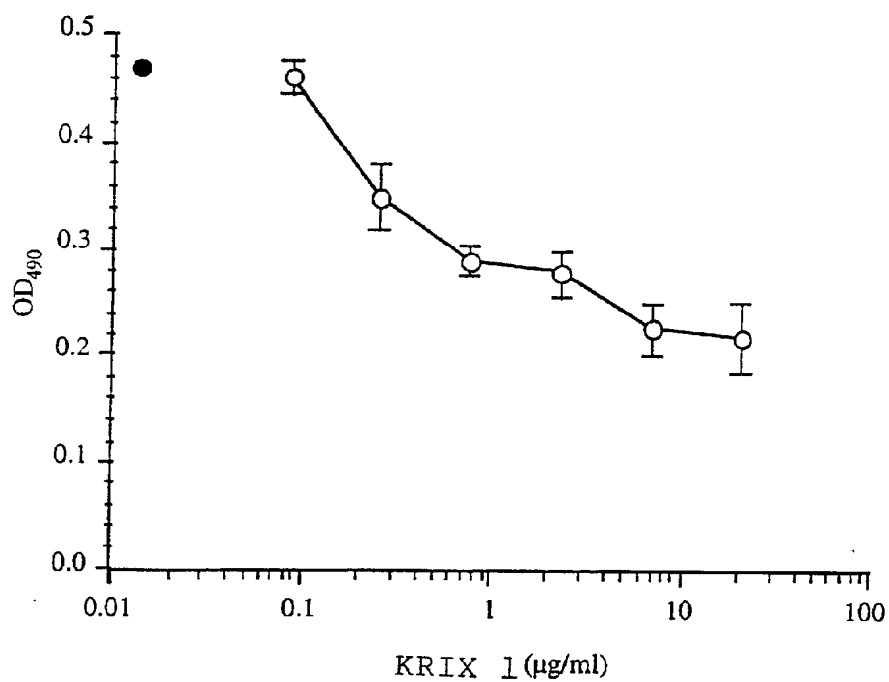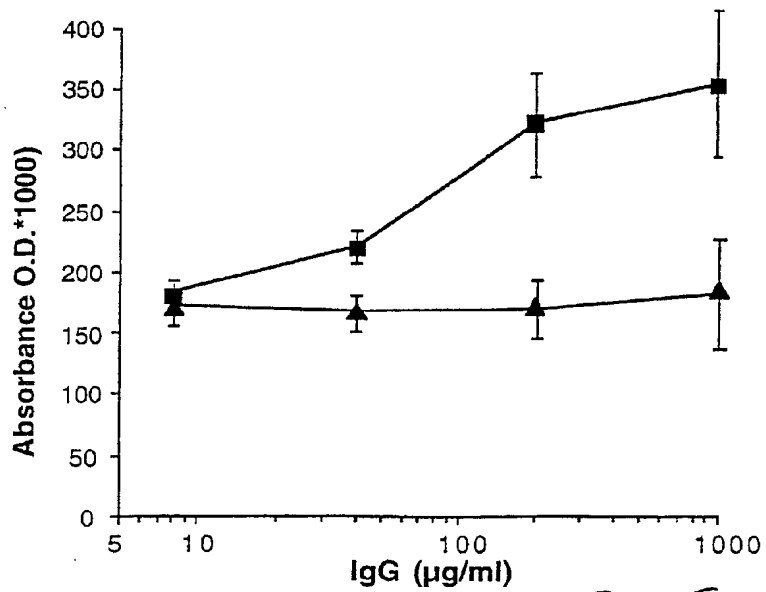* Inhibition of FVIII activity in coagulation assay

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5
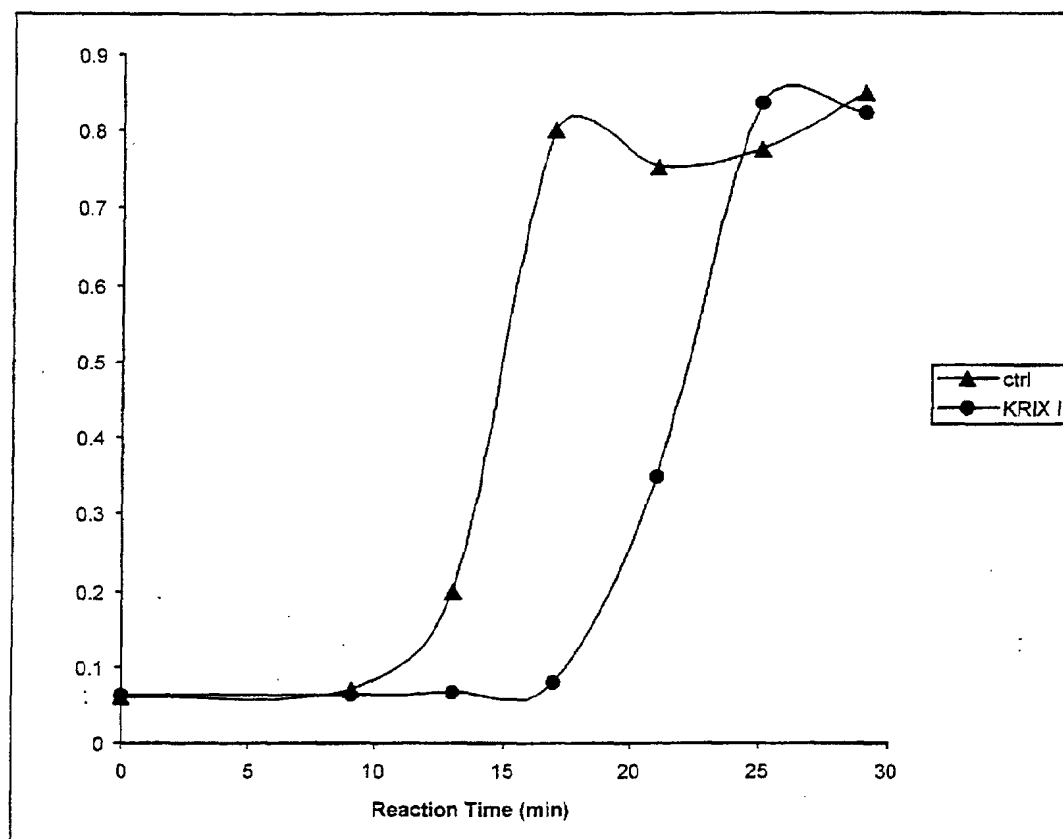
FiG. 6

Figure 7

Figure 8

Figure 9

Fibrinogen plasma levels in
wildtype and FVIII KO C57Bl/6
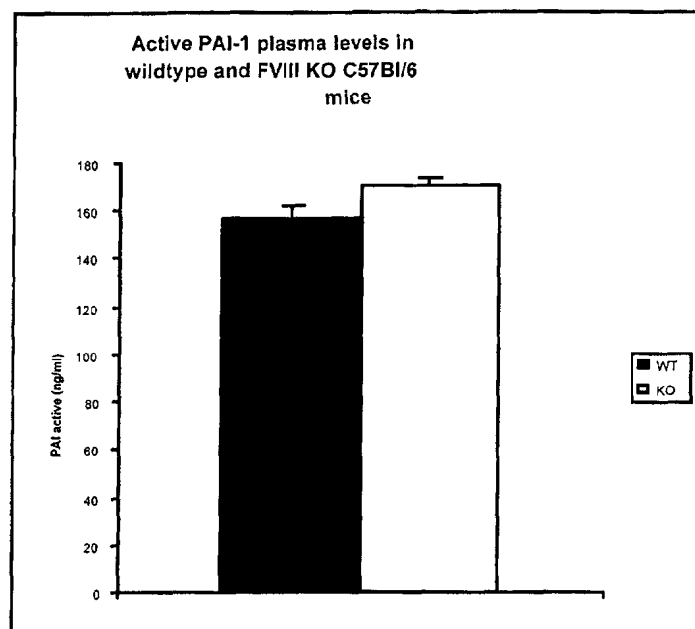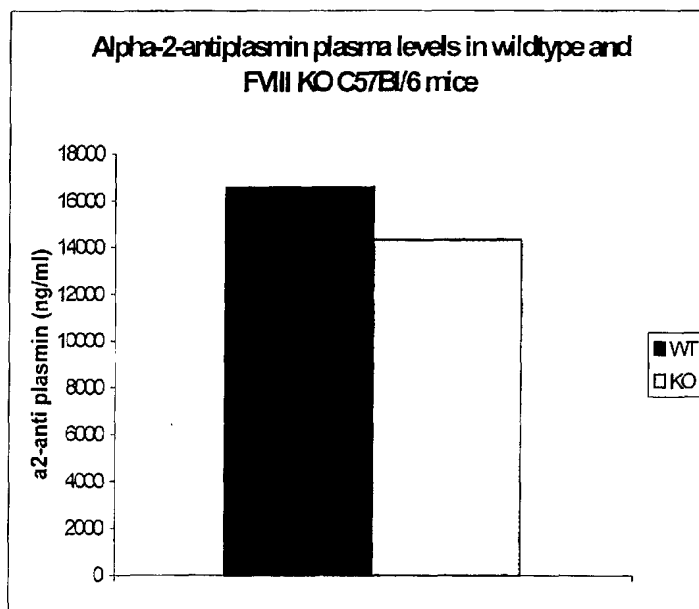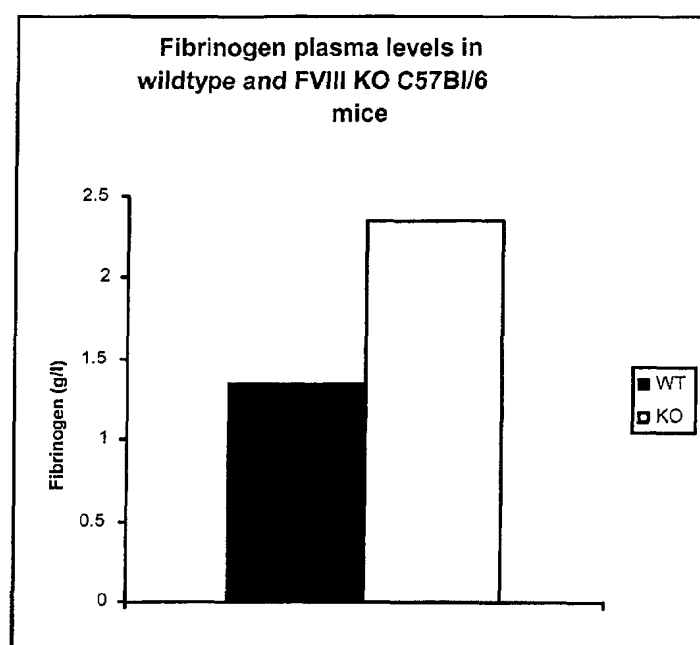mice

VH BO 2C11

```
1                                                              60
atg gac tgg acc tgg agg atc ctc ttc ttg gtg gca gca gct aca ggc acc cac gcc cag
Met Asp Trp Thr Trp Arg Ile Leu Phe Leu Val Ala Ala Ala Thr Gly Thr His Ala Gln
1                                                              20


61                                                             120
gtc caa ctg gta cag tct ggg gct gag gtg aag aag cct ggg gcc tca gtg aag gtc tcc
Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Pro Gly Ala Ser Val Lys Val Ser
21                                                             40


121                                                            180
tgc aag gtt tcc gga tac acc ctc act gaa tta ccc gtg cac tgg gtc gga cag gct cct
Cys Lys Val Ser Gly Tyr Thr Leu Thr Glu Leu Pro Val His Trp Val Gly Gln Ala Pro
41              ←-------------CDR1-------------------→          60


181                                                            240
gga aaa ggg ctt gag tgg gtg gga agt ttt gat cct gaa agt gga gaa tca atc tac gca
Gly Lys Gly Leu Glu Trp Val Gly Ser Phe Asp Pro Glu Ser Gly Glu Ser Ile Tyr Ala
61                        ←----------------------------CDR2----------------80


241                                                            300
cgg gag ttc cag ggc agc gtc acc atg acc gcg gac aca tct aca gac ata gcc tac atg
Arg Glu Phe Gln Gly Ser Val Thr Met Thr Ala Asp Thr Ser Thr Asp Ile Ala Tyr Met
81------------------------→                                     100


301                                                            360
gag ctg agc agc ctg aga tct gac gac acg gcc gtg tat tac tgt gca gtc cct gac cct
Glu Leu Ser Ser Leu Arg Ser Asp Asp Thr Ala Val Tyr Tyr Cys Ala Val Pro Asp Pro
101                                             ←----------CDR3---120


361                                                            420
gat gct ttt gat atc tgg ggc caa ggg aca atg gtc acc gtc tct tca gcc tcc acc aag
Asp Ala Phe Asp Ile Trp Gly Gln Gly Thr Met Val Thr Val Ser Ser Ala Ser Thr Lys
121---------------→                                             140


421                              450
ggc cca tcg gtc ttc ccc ctg gga tcc cgt
Gly Pro Ser Val Phe Pro Leu Gly Ser Arg
141                              150
```

FIGURE 10

VL BO 2C11

```
1                                                              60
atg gaa acc cca gct cag ctt ctc ttc ctc ctg cta ctc tgg ctc cca gat acc acc gga
Met Glu Thr Pro Ala Gln Leu Leu Phe Leu Leu Leu Leu Trp Leu Pro Asp Thr Thr Gly
1                                                              20


61                                                            120
gaa att gcg ttg acg cag tct cca ggc acc ctg tct ttg tct cca ggg gaa aga gcc acc
Glu Ile Ala Leu Thr Gln Ser Pro Gly Thr Leu Ser Leu Ser Pro Gly Glu Arg Ala Thr
21                                                             40


121                                                           180
ctc tcc tgc agg gcc agt cag agt ttt agc agc agc tac tta gcc tgg tat cag cag aaa
Leu Ser Cys Arg Ala Ser Gln Ser Phe Ser Ser Ser Tyr Leu Ala Trp Tyr Gln Gln Lys
41             ←------------CDR1--------------------------------→       60


181                                                           240
cct ggc cag gct ccc agg ctc ctc atc tat ggt gca tcc acc agg gcc act ggc atc cca
Pro Gly Gln Ala Pro Arg Leu Leu Ile Tyr Gly Ala Ser Thr Arg Ala Thr Gly Ile Pro
61                                  ←----------CDR2-----------→       80


241                                                           300
gac agg ttc agt ggc agt ggg tct ggg aca gac ttc act ctc acc atc agc aga ctg gag
Asp Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Arg Leu Glu
81                                                             100


301                                                           360
cct gaa gat ttt gca gtg tat tac tgt cag aag tat ggt acg tca gcg atc acc ttc ggg
Pro Glu Asp Phe Ala Val Tyr Tyr Cys Gln Lys Tyr Gly Thr Ser Ala Ile Thr Phe Gly
101                              ←---------CDR3--------------------→      120


361                                                           420
caa ggg aca cga ctg gag att aaa gga act gtg gct gca cca tct gtc ttc atc ttc ccg
Gln Gly Thr Arg Leu Glu Ile Lys Gly Thr Val Ala Ala Pro Ser Val Phe Ile Phe Pro
121                                                            140


421 426
cca tct
Pro Ser
141 142
```

Figure 11

VH KRIX -1

```
1                                                                      60
atg gac tgg acc tgg agg atc ctc ttc ttg gtg gca gca gcc aca gga gcc cac tcc cag
Met Asp Trp Thr Trp Arg Ile Leu Phe Leu Val Ala Ala Ala Thr Gly Ala His Ser Gln
1                                                                      20


61                                                                     120
gtg caa ctg gtg caa tct ggg gct gag gtg aag aag cct ggg gcc tca gtg aag gtc tcc
Val Gln Leu Val Gln Ser Gly Ala Glu Val Lys Lys Pro Gly Ala Ser Val Lys Val Ser
21                                                                     40


121                                                                    180
tgc aag acc tct gga tac aac ttc acc ggc tac tct gct tct gga cat atc ttc acc gcc
Cys Lys Thr Ser Gly Tyr Asn Phe Thr Gly Tyr Ser Ala Ser Gly His Ile Phe Thr Ala
41  ←------------------------------CDR1-------------------------------60


181                                                                    240
tac tct gtg cac tgg gtg cga cag gcc cct gga caa ggg ctt gag tgg atg gga agg atc
Tyr Ser Val His Trp Val Arg Gln Ala Pro Gly Gln Gly Leu Glu Trp Met Gly Arg Ile
61------------→                                              ←----80


241                                                                    300
aac cct aac agt ggt gcc aca gac tat gca cat aaa ttt cag ggc agg gtc acc atg tcc
Asn Pro Asn Ser Gly Ala Thr Asp Tyr Ala His Lys Phe Gln Gly Arg Val Thr Met Ser
81----------CDR2-------------------------------------------→        100


301                                                                    360
agg gac acg tcc atc agc aca gcc tac atg gaa ctg agc agg ctg aca tct gac gac acg
Arg Asp Thr Ser Ile Ser Thr Ala Tyr Met Glu Leu Ser Arg Leu Thr Ser Asp Asp Thr
101                                                                    120


361                                                                    420
gcc atg tat tac tgt gcg aga gcc gac aac tat ttc gat att gtg act ggc tat act tct
Ala Met Tyr Tyr Cys Ala Arg Ala Asp Asn Tyr Phe Asp Ile Val Thr Gly Tyr Thr Ser
121               ←------------------------CDR3-----------------140


421                                      468
cat tac ttt gac tac tgg ggc cgg gga acc ctg gtc acc gtc tcc tca
His Tyr Phe Asp Tyr Trp Gly Arg Gly Thr Leu Val Thr Val Ser Ser
141---------------→                                      156
```

Figure 12

VL KRIX 1

```
1                                                                              60
atg gaa acc cca gct cag ctt ctc ttc ctc ctg cta ctc tgg ctc cca gat acc acc gga
Met Glu Thr Pro Ala Gln Leu Leu Phe Leu Leu Leu Leu Trp Leu Pro Asp Thr Thr Gly
1                                                                              20

61                                                                             120
gaa att gtg ttg acg cag ttc cca ggc acc ctg tct ttg tct cca ggg gaa aga gcc acc
Glu Ile Val Leu Thr Gln Phe Pro Gly Thr Leu Ser Leu Ser Pro Gly Glu Arg Ala Thr
21                                                                             40


121                                                                            180
ctc tcc tgc agg gcc agt cag agt gtt gcc agc gcc tac tta gcc tgg tac cag caa aaa
Leu Ser Cys Arg Ala Ser Gln Ser Val Ala Ser Ala Tyr Leu Ala Trp Tyr Gln Gln Lys
41               ←------------------CDR1------------------------→               60


181                                                                            240
cct ggc cag gct ccc agg ctc ctc atc tat ggt gca tcc agt agg gcc acc gac atc cca
Pro Gly Gln Ala Pro Arg Leu Leu Ile Tyr Gly Ala Ser Ser Arg Ala Thr Asp Ile Pro
61                                    ←------- CDR2-----------→                  80

241                                                                            300
cac agg ttc agt ggc agt ggg tct ggg aca gac ttc act ctc acc atc agc aga ctg gag
His Arg Phe Ser Gly Ser Gly Ser Gly Thr Asp Phe Thr Leu Thr Ile Ser Arg Leu Glu
81                                                                             100

301                                                                            360
cct gaa gat ttt gca gtg tac tac tgt cag caa tat ggt acc tca gcc tta ctc act ttc
Pro Glu Asp Phe Ala Val Tyr Tyr Cys Gln Gln Tyr Gly Thr Ser Ala Leu Leu Thr Phe
101                                    ←---------CDR3----------------------→     120


361                                                                            420
ggc gga ggg acc aag gtg gag atc aaa cga act gtg gct gca cca tct gtc ttc atc ttc
Gly Gly Gly Thr Lys Val Glu Ile Lys Arg Thr Val Ala Ala Pro Ser Val Phe Ile Phe
121                                                                            140


420     429
ccg cca tct
Pro Pro Ser
141     143
```

FIGURE 13